ADMINISTRATIVE INFORMATION

1. **Project Name:** High Density Infrared Surface Treatments of Refractories

2. **Lead Organization:** Oak Ridge National Laboratory
Oak Ridge, TN 37831-6087

3. **Principal Investigator:** Terry Tiegs
Telephone: 865-574-5173
FAX: 865-574-4357
Email: tiegstn@ornl.gov

Co-Investigators:
Craig Blue
Dave Harper
Fred Montgomery

4. **Project Partners:** University of Missouri – Rolla (subcontractor)
Bill Headrick

Allied Mineral, Inc. (material supplier)
Dana Goski

Emhart Glass Co. (material supplier)
Steve Herrington

Magneco-Metrel, Inc. (material supplier)
Mike Anderson

5. **Date Project Initiated:** October 1, 2001 (FY2002)

6. **Expected Completion Date:** September 30, 2004

PROJECT RATIONALE AND STRATEGY

7. **Project Objective:**

The overall goals of the project are to make a major advancement in improving the behavior of refractory materials used in industrial processing. The benefits of high density infrared (HDI) processing of refractories would be to: (1) reduce surface porosity (by essentially sealing the surface to prevent liquid penetration), (2) allow surface chemistry changes that would inhibit wetting and/or corrosion, and (3) improve mechanical properties.

8. **Technical Barrier(s) Being Addressed:**

No major technical barriers appear to be a problem. However, cracking of the materials due to thermal shock is a concern since the cracks may circumvent any improvement in corrosion resistance of the surface. In addition, economic barriers to application of the technology are present. Near-

term use will concentrate on applications that require high performance and can justify the increased cost of refractories.

9. **Project Pathway:**

Modification of the HDI processing to minimize thermal shock and prevent cracking was instituted. Economics indicated that the project should concentrate on high value expendable refractory items that would benefit from improved performance.

10. **Critical Technical Metrics:**

Baseline metric:
Aluminosilicate expendable refractory parts used in molten glass contact applications show significant glass penetration and corrosion. Lifetimes are typically 2 to 4 months.

Project metric;
Demonstrate reduced penetration and corrosion of HDI-coated aluminosilicate expendable refractories.

PROJECT PLANS AND PROGRESS

11. **Past Accomplishments:**

FY 2002 Summary - HDI treatment of commercial refractories showed that surface melting was plainly evident at moderate power levels ($\geq$1375 watts/cm^2) for the aluminosilicate-based materials. The more refractory high alumina compositions required power levels $\geq$2025 watts/cm^2 to produce melted surfaces. During solidification of the surface melted region on alumino-silicate materials, the mullite grains that formed were highly oriented with the c-axis perpendicular to the surface. Preliminary corrosion testing showed the HDI treatment was effective in reducing penetration by molten copper.

FY 2003 Activities – The project examined changes in surface chemistry by bonding an adherent coating onto the underlying refractory that would inhibit wetting and/or corrosion. Adherent surface coatings of spinel and zirconia have been applied to numerous refractories. Improved corrosion resistance was shown with zirconia or spinel coatings on either alumina-zirconia-silica (AZS) or aluminosilcate refractories in glass melts.

FY 2004 Activities – Current activities are designed to develop refractories with high emissivity surfaces on non-contact refractories. Most of the work is concerned with fibrous materials.

ID Number	Task / Milestone Description	Planned Completion	Actual Completion	Comments
1	Demonstrate surface porosity reduction on oxide-based refractories and show improved corrosion resistance in simulated process environments.	9/30/02	9/30/02	Completed
2	Fabricate corrosion-resistant surface layers on refractories by either diffusion coating or selective sintering of secondary layers.	9/30/03	9/30/03	Completed
3	Produce refractories having high emissivity surface coatings.	9/30/04		Pending

12. **Future Plans:**

• Complete work on producing refractories with high emissivity surfaces.

13. **Project Changes:**

Under the current program there have been no changes in the project direction or timetable.

14. **Commercialization Potential, Plans, and Activities:**

Samples of high density infrared surface treated refractories will be supplied to companies for testing at their facilities. The initial samples will be expendable parts to be used for testing in a glass contact application.

15. **Patents, Publications, Presentations:**

Patents
Invention disclosure filed with UT-Battelle patent office. September 2002.

Publications
1. T. N. Tiegs, J. O. Kiggans, F. C. Montgomery, C. A. Blue, and M. Velez, "HDI Surface Treatment of Ceramics," Am. Ceram. Soc. Bull., 82 [2] 49-53 (2003).

2. T. N. Tiegs, J. O. Kiggans, F. C. Montgomery, C. A. Blue, "High Density Infrared Surface Treatment of Ceramics," Ceram. Transactions, Vol. 135, 239-246, Am. Ceram. Soc., Westerville, OH (2002).

3. T. N. Tiegs, J. O. Kiggans, F. C. Montgomery, D. C. Harper, and C. A. Blue, "Surface Modification of Ceramics By High Density Infrared Heating," Ceram. Eng, Sci. Proceed., 24[3] 477-482, Am. Ceram. Soc., Westerville, OH (2003).

4. T. N. Tiegs, F. C. Montgomery, D. C. Harper, C. A. Blue, M. Velez, M. Karakus, and R. E. Moore, "Surface Treatment of AZS Refractories Using High Density Infrared Heating," pp. 3-12 in Proceed., of 64th Conference on Glass Problems, Am. Ceram. Soc., Westerville, OH (2004).

Presentations

1. Presentation made at the American Ceramic Society Annual Meeting in St. Louis, MO, April 29-May 1, 2002 entitled, "High Density Infrared Surface Treatment of Ceramics."

2. Presentation made at the American Ceramic Society Pacific Coast Meeting in Seattle, WA Oct. 1-4 entitled," Surface Treatment of Refractories By High Intensity Infrared Heating."

3. Presentation made at the American Ceramic Society Meeting on Advanced Materials in Cocoa Beach, FL, Jan, 27-31, entitled," Surface Modification of Ceramics By High Density Infrared Heating."

4. Presentation made at the 64th Conference on Glass Problems in Urbana, IL, Oct. 28, 2003, entitled "Surface Treatment of AZS Refractories Using High Density Infrared Heating."

5. Presentation made at the 35th Symposium of the Society for Glass Science and Practices on May 6, 2004 in Wheeling, WV, entitled "Surface Treatment of Refractories For Glass Contact Applications."

6. Presentation made at the American Ceramic Society Annual Meeting in Indianapolis, IN, April 20, 2004 entitled, "Ceramic Coatings on Refractories Produced by High Intensity Infrared Heating."